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CONNECTOR INCLUDING REDUCED CROSSTALK SPRING INSERT

This is a continuation of application no. 09/231,736, filed 01/15/99, now USPN 6,334,792.

Field of the Invention

The present invention relates to electrical connectors, and specifically to electrical connectors having closely spaced contacts where interference from crosstalk in the connector is a concern.

Background of the Invention

Various electrical connectors are known for use in the telecommunications industry to transmit voice, data, and video signals. It is common for some electrical connectors to be configured to include a plug which is connectable to a jack mounted in the wall, or as part of a panel or other telecommunications equipment mounted to a rack or cabinet. The jack includes a housing which holds a plurality of closely spaced spring contacts in the appropriate position for contacting the contacts of a plug inserted into the jack. The spring contacts of the jack are often mounted to a printed circuit board, either vertically or horizontally. An RJ45 plug and jack connector system is one well known standard including closely spaced contacts.

Crosstalk between the contacts in telecommunications connectors is a concern due to the close spacing of the contacts. U.S. Patent Nos. 5,399,107; 5,674,093; and 5,779,503 are examples of various connectors including jacks and plugs which attempt to address the problem of crosstalk. It is desired to improve performance of the electrical connectors, such as an RJ45 connector, where crosstalk problems increase as higher frequencies are transmitted through the connector.

Summary of the Invention

One aspect of the present invention relates to an electrical connector for connecting to a plug having a plurality of electrical contacts, the connector including a plurality of first and second metallic spring contacts. Each of the first and second spring contacts includes: 1) a circuit board connection end for connecting to a circuit board; 2) a first longitudinally extending section; 3) a main bend section; and 4) a second longitudinally extending section engageable with a contact of the plug. The first

longitudinally extending section, the main bend section, and the second longitudinally extending section define a general V–shape. The second longitudinally extending section of the first spring contacts have two linear portions joined at a bend portion. The second longitudinally extending section of the second spring contacts extends linearly. A dielectric contact housing holds the spring contacts, wherein the contact housing defines an x–axis, a y–axis and a z–axis. The contact housing is configured for receipt of the plug in a direction of the x–axis, wherein the first and second spring contacts are arranged such that: 1) the first and second spring contacts alternate along the z–axis; 2) the first longitudinally extending sections of the first spring contacts are in a plane displaced along the y–axis from a plane defined by the first longitudinally extending sections of the second spring contacts; and 3) the main bends of the first spring contacts are displaced along the x–axis from the main bends of the second spring contacts.

A printed circuit board is mounted to the first and second spring contacts at the circuit board connection ends. The printed circuit board may define either a plane parallel to the x and z–axes, or a plane parallel to the y and z axes.

In the case of a one preferred embodiment, the contact housing includes a base for receiving each of the first longitudinally extending sections of the first and second spring contacts, wherein the base defines at least one channel extending in the direction of the x–axis between the first longitudinally extending sections of the first spring contacts and the first longitudinally extending sections of the second spring contacts. In the case of another preferred embodiment, the contact housing includes a base having a divider extending from a top surface, with the divider defining a plurality of alternating first and second channels. Each of the first and second channels receives one of the first and second spring contacts. The first channels extend at an angle to the x and y–axes, and the second channels extend parallel to the x–axis.

Another aspect of the present invention relates to an electrical connector for connecting to a plug having a plurality of electrical contacts where the connector includes a plurality of first and second metallic spring contacts. Each of the first and second spring contacts includes: 1) a circuit board connection end for connecting to a circuit board; 2) a first longitudinally extending section; 3) a main bend section; and 4) a second longitudinally extending section. The first longitudinally extending section,

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the main bend section, and the second longitudinally extending section define a general V–shape. A dielectric contact housing holds the spring contacts, wherein the contact housing defines an x–axis, a y–axis and a z–axis. The contact housing is configured for receipt of the plug in a direction of the x–axis, wherein the first and second spring contacts are arranged such that: 1) the first and second spring contacts alternate along the z–axis; 2) the first longitudinally extending sections of the first spring contacts are in a plane displaced along the y–axis from a plane defined by the first longitudinally extending sections of the second spring contacts; and 3) the contact housing including a base for receiving each of the first longitudinally extending sections of the first and second spring contacts, wherein the base defines at least one channel extending in the direction of the x–axis between the first longitudinally extending sections of the first spring contacts and the first longitudinally extending sections of the second spring contacts.

Brief Description of the Drawings

FIG. 1 is a perspective view of a jack assembly in accordance with the present invention including two jacks, each for receiving a plug;

FIG. 2 is a cross–sectional side view of the jack assembly of FIG. 1 through one of the jacks and showing a vertically mounted printed circuit board;

FIG. 3 is a perspective view of the vertical insert assembly used in the jack assembly of FIG. 1;

FIG. 4 is an end view of the vertical insert assembly of FIG. 3;

FIG. 5 is a top view of the vertical insert assembly of FIG. 3;

FIG. 6 is an opposite end view of the vertical insert assembly of FIG. 3 to the view of FIG. 3;

FIG. 7 is a bottom view of the vertical insert assembly of FIG. 3;

FIG. 8 is a side view of the vertical insert assembly of FIG. 3;

FIG. 9 is a cross–sectional side view of the vertical insert assembly of FIG. 3, taken along lines 9–9 of FIG. 5;

FIG. 10 is a further cross–sectional side view of the vertical insert assembly of FIG. 3, taken along lines 10–10 of FIG. 5;

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FIG. 11 is a cross–sectional side view like the view of FIG. 9, showing a plug with its contacts in electrical contact with the spring contacts of the vertical insert assembly;

FIG. 12 is a further cross–sectional side view like the view of FIG. 10, showing the plug in electrical contact with the spring contacts of the vertical insert assembly;

FIG. 13 is a side view of the two configurations of the spring contacts of the vertical insert assembly of FIG. 3, shown in their relative positions;

FIG. 14 is a perspective view of the contact housing of the vertical insert assembly of FIG. 3;

FIG. 15 is an end view of the contact housing of FIG. 14;

FIG. 16 is a perspective view of a horizontal insert assembly for use with a horizontally mounted printed circuit board, for an alternative jack assembly;

FIG. 17 is an end front view of the horizontal insert assembly of FIG. 16;

FIG. 18 is a top view of the horizontal insert assembly of FIG. 16;

FIG. 19 is a bottom view of the horizontal insert assembly of FIG. 16;

FIG. 20 is a cross–sectional side view of the horizontal insert assembly of FIG. 16, taken along lines 20–20 of FIG. 18;

FIG. 21 is a further cross–sectional side view of the horizontal insert assembly of FIG. 16, taken along lines 21–21 of FIG. 18;

FIG. 22 is a cross–sectional side view of the horizontal insert assembly like the view of FIG. 20, showing a plug in electrical contact with the spring contacts of the horizontal insert assembly;

FIG. 23 is a further cross–sectional side view of the horizontal insert assembly like the view of FIG. 21, showing the plug in electrical contact with the spring contacts of the horizontal insert assembly;

FIG. 24 is a side view of the two configurations of the spring contacts of the horizontal insert assembly of FIG. 16, shown in their relative positions;

FIG. 25 is a perspective view of the contact housing of the horizontal insert assembly of FIG. 16;

FIG. 26 is an end view of the contact housing of FIG. 25; and

FIG. 27 is a top view of the contact housing of FIG. 25.

Detailed Description of the Preferred Embodiments

The present invention is concerned with improving performance of electrical connectors including closely spaced electrical contacts where crosstalk may be a problem, especially as increasingly higher frequency signals are desired for use with the electrical connectors.

FIGS. 1 and 2 show an example of one jack assembly 10 including two jacks 12 each sized for receipt of a plug 14 (See FIGS. 11, 12, 22 and 23). Plug 14 typically includes a plurality of metallic contacts 16, 18 for making contact with electrical spring contacts 40, 42 within each jack 12. Contacts 16, 18 are housed in a housing 20 of plug 14. Plug 14 also includes a latching tab 22 for mounting plug 14 to jack 12. As shown in the illustrated preferred embodiments, jack 12 and plug 14 are 8 contact type (4 twisted pair) connectors as in an RJ45 connector.

As shown in FIG. 2, each jack 12 includes a cavity 30 for receipt of plug 14. An outer housing 32 encloses an insert assembly 34. In the example of FIG. 2, insert assembly 34 is a vertical insert assembly including a vertically mounted printed circuit board 36. Insert assembly 34 further includes a plurality of metallic spring contacts 40, 42 mounted to a contact housing 44. Spring contacts 40, 42 have first ends 50, 52 disposed within cavity 30 for contacting contacts 18, 20 of plug 14. Spring contacts 40, 42 define a general V-shape. First ends 50, 52 flex inwardly as the plug 14 is inserted into cavity 30. Opposite ends 54, 56 of spring contacts 40, 42 extend from contact housing 44 to mount to printed circuit board 36, such as by soldering.

While the present invention is particularly useful in an RJ45 connector, other connectors including jack and plug arrangements where the electrical contacts are held in close proximity may also benefit by including one or more of the features disclosed herein for reducing crosstalk.

With respect to an RJ45 connector, there are eight contacts. The plugs and jacks have eight aligned contacts 1-2-3-4-5-6-7-8 (4 each of contacts 16, 18, and spring contacts 40, 42, respectively, each arranged in an alternating manner). See the example embodiments of FIGS. 6 and 19 for the contact numbering. The plug contacts have four pairs of twisted pair cable terminated to them. These pairs are typically paired as follows: 4-5, 3-6, 1-2 and 7-8. Because of the pair arrangement, there is unbalanced capacitance and inductance which creates the crosstalk between

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pairs 2–3, 3–4, 5–6 and 6–7. Therefore, it is desirable that these contacts be isolated as much as possible from each other within the jack. Furthermore, the pairs in the jack can be balanced by positioning certain contact combinations together to cancel crosstalk. These pair combinations are 1–3, 2–4, 3–5, 4–6, 5–7 and 6–8. Therefore, it is desirable for the jack to have a lower amount of coupling between contacts 2–3, 3–4, 5–6 and 6–7, and to have a higher amount of coupling between contacts 1–3, 2–4, 3–5, 4–6, 5–7 and 6–8.

The present invention utilizes various features in the jack in the preferred embodiments to address crosstalk concerns. Staggering every other spring contact (1, 3, 5 and 7 in one row, and 2, 4, 6 and 8 in the other row, see FIG. 6) allows for the spring contacts to be moved further apart where isolation is desired, and the spring contacts where coupling is desired to be increased, are positioned closer to each other. The spring contacts are also positioned so that they are not in the same contact plane for a significant portion. The free ends of the spring contacts are in the same plane at the contact area with the plug, but before and after they are not in the same plane. (See FIGS. 11 and 12). Each set of four spring contacts pivots at a location that is not in line with the other set of four spring contacts. (See FIGS. 9, 10 and 13). Additionally, the set of four spring contacts which has a smaller angle relative to the other set has a further bend after its contact point with the plug to further increase the isolation between the spring contacts. Further, the contact housing utilizes air spaces in selected locations to further isolate certain spring contacts, and solid material in other selected locations to increase coupling. Positioning material with a higher dielectric constant will increase the coupling and, therefore, crosstalk between two conductors, and air, which has a lower dielectric constant than the housing material, will have less coupling between the two spring contacts. While all of the above noted features are preferred, variations are possible which utilize one or more selected features to improve performance by reducing crosstalk.

Referring now to FIGS. 3–15, vertical insert assembly 34 is shown in greater detail. Contact housing 44 includes a base 46 having a front 60, a top 62, a bottom 64, and a rear 66. It is to be appreciated that contact housing 44 can be positioned in any orientation as desired in jack assembly 10 or other mounting

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arrangement. Vertical insert assembly 34 in FIGS. 3–15 defines an x–axis, a y–axis and a z–axis (See FIG. 3) for purposes of this description.

Base 46 includes two sets of longitudinal openings 78 and 80 arranged in a row, each for receipt of a spring contact 40, 42. Longitudinal openings 78, 80 extend in the direction of the x–axis. Each set is staggered in the y–axis direction to facilitate spacing of selected spring contacts to isolate some and couple others. Front channels 82, 84 communicate with longitudinal openings 78, 80, and also receive spring contacts 40, 42. Each first front channel 82 communicates with one of first longitudinal openings 78 to receive one first spring contact 40. Each second front channel 84 communicates with one of second longitudinal openings 80 to receive one second spring contact. Second front channels 84 are deeper than first front channels 82 in the x–axis direction. This results in spacing of the spring contacts 40, 42 in the x–axis direction at the apex region of each spring contact, and along the free ends except for the contact areas. Base 46 further includes top and bottom openings or channels 88, 90 to facilitate manufacture of contact housing 44 from molded materials, such as plastic, for example polyetherimide.

Base 46 further includes longitudinal channels or passageways 92, 94 positioned between the sets of longitudinal openings 78, 80. This results in better decoupling of selected spring contacts, as noted above.

First spring contact 40 includes a board contact end section 100, and a coaxial and longitudinally extending main section 102 positioned in longitudinal opening 78 in base 46. A front bend 104 is positioned in front channel 82 of base 46. Longitudinal contact section 106 extends upwardly at an angle from base 46 in the FIGS. so as to be positioned in the cavity 30 of the jack 12 for electrical contact with the plug 14. Contact section 106 further includes a bend region 108 which positions bend region 108 at an angle relative to a remainder of contact section 106. Contact section 106 of spring contact 40 is comprised of two linear segments in the illustrated embodiment.

Second spring contact 42 includes a board contact end section 110, and a longitudinally extending main section 112, both of which extend parallel to board contact section 100 and longitudinally extending main section 102 of first spring contact 40. A front bend 114 is positioned in front channel 84 of base 46. Front bend 114 is

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larger in height than front bend 104 of first spring contact 40. Second spring contact 42 includes a longitudinal contact section 116 extending upwardly at an angle from base 46 so as to be positioned in the cavity 30 of the jack 12 for electrical contact with the plug 14. Contact section 116 of spring contact 42 is comprised of a linear segment in the illustrated embodiment Both of spring contacts 40, 42 are convenient shapes to manufacture and maintain with a sufficient amount of flexibility to achieve proper contact with the contacts of plug 14.

As shown by referencing FIGS. 3–15, longitudinally extending sections 102, 112 are staggered in the y–axis direction in base 46. Front bends 104, 114 are staggered in the x–axis direction, and bend 108 positions the distal end 109 of spring contact 40 at an angle relative to distal end 118 of contact section 116 of second spring contact 42. Further, base 46 advantageously positions base material between spring contacts 40, 42 where more coupling is desired, and air is advantageously positioned in other selected areas between longitudinal passageways 92, 94 between spring contacts where less coupling between contacts is desired. In this manner, jacks 12 can be provided which address crosstalk concerns such as in catagory 6 systems, with bandwidths of 250 Megahertz.

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Referring now to FIGS. 16–27, a horizontal insert assembly 134 is shown including a contact housing 144 and two sets of spring contacts 140, 142. Contact housing 144 includes a base 146 defining a front 160, a top 162, a bottom 164 and a rear 166. Horizontal insert assembly 134 defines an x–axis, a y–axis, and a z–axis (See FIG. 16) for the purposes of this description. It is to be appreciated that horizontal insert assembly 134 can be mounted in any orientation as desired in a jack assembly. Horizontal insert assembly 134 includes a horizontally positioned printed circuit board 150 (See FIGS. 20 and 21), instead of a vertical mount as in vertical insert assembly 34.

Base 146 includes to opposed sidewalls 152, and a rear connector assembly 154 for terminating wires to horizontal insert assembly 134. Base 146 includes a divider 180 for positioning individual first and second spring contacts 140, 142. Divider 180 has side walls which define first and second channels 182, 184. Each of first channels 182 includes a slight angled surface 186, angled relative to the x and y–axes. Second channels 184 each include a longitudinal surface 188 extending generally

parallel to the x–axis, and at a lower elevation from surface 186 along the y–axis. Base 146 further includes openings 190, 192 for allowing spring contacts 140, 142 to pass through base 146 in the direction of the y–axis. Both first and second spring contacts 140, 142 define a general V–shape.

First spring contact 140 includes a board contact end section 200, a first bend 202, followed by a main longitudinal section 204 for receipt in angled surface 186. A second bend 206 is followed by a longitudinal contact section 208. A further bend 210 positions distal end 209 of contact section 208 at an angle relative to a remainder of contact section 208. Second spring contact 142 includes a board contact end section 220, a first bend 222, followed by a longitudinal main section 224 which resides in second channel 184. Second spring contact 142 further includes a second bend 226 followed by a longitudinal contact section 228.

As shown in the FIGS., board contact end sections 200, 220 are staggered in two rows as shown in FIG. 19. Main sections 204, 224 are not parallel, and one set of spring contacts 140 includes a bend 210 in the contact section 208 which positions the distal ends of spring contacts 140, 142 so that the ends are not parallel. Also, bends 206, 226 are positioned such that the pivot points of spring contacts 140, 142 are not in the same line. These features cooperate to isolate selected spring contacts to reduce crosstalk especially at higher frequencies as may be encountered in a catagory 6 standard.

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While the various features of each of horizontal insert assembly 134 and vertical insert assembly 34 cooperate in an advantageous manner, it is to be appreciated that the noted features may be used individually or in various combinations as desired to address crosstalk concerns. Also, while horizontally mounted printed circuit boards and vertically mounted printed circuit boards are shown, it is to be appreciated that angled printed circuit boards are also possible with an appropriately configured contact housing.

The above specification, examples and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

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